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Ball joint assembly in a steering system

Abstract:

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In a ball joint assembly and a steering system which includes such an assembly a universal joint is provided between a rack bar 1 and a tie rod 3. Screw threaded for axial adjustment on the bar 1 is a tubular housing 2 which captures a ball cup 5, on the rod 3. Part-spherical inner and outer bearing surfaces 11 and 8 slidably co-operatre between the housing and ball cup and the latter has a part spherical inner bearing surface 7 within which is received a resilient plastics ball 14. A socket 15 of the ball is mounted on a spigot 13 of the bar 1. By screw adjustment of the housing 2 on the bar 1 the ball 14 is axially compressed between the bar and the bearing surface 7 to pre-load the universal joint by the consequential expansive forces in the ball 14. The housing 2 can be pre-formed to capture the ball cup 5 or can be swaged over the bearing surface 8 of the ball cup so that during the swaging operation the ball 14 is pre-loaded. In a modification (Figure 4, not shown) the ball 14 is spherical and is restrained radially relative to the bar 1 by mounting within a part spherical seating in the end of the bar.

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(54) Ball joint assembly in a steering system

(57) In a ball joint assembly and a steering system which includes such an assembly a universal joint is provided between a rack bar 1 and a tie rod 3. Screw threaded for axial adjustment on the bar 1 is a tubular housing 2 which captures a ball cup 5, on the rod 3. Part-spherical inner and outer bearing surfaces 11 and 8 slidably co-operatre between the housing and ball cup and the latter has a part spherical inner bearing surface 7 within which is received a resilient plastics ball 14. A socket 15 of the ball is mounted on a spigot 13 of the bar 1. By screw adjustment of the housing 2 on the bar 1 the ball 14 is axially compressed between the bar and the bearing surface 7 to pre-load the universal joint by the consequential expansive forces in the ball 14.

The housing 2 can be pre-formed to capture the ball cup 5 or can be swaged over the bearing surface 8 of the ball cup so that during the swaging operation the ball 14 is pre-loaded. In a modification (Figure 4, not shown) the ball 14 is spherical and is restrained radially relative to the bar 1 by mounting within a part spherical seating in the end of the bar.

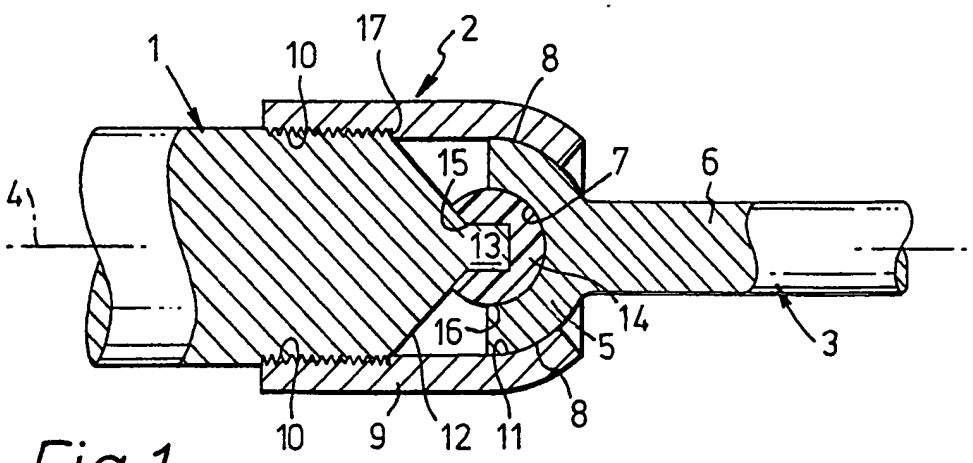

Fig.1.

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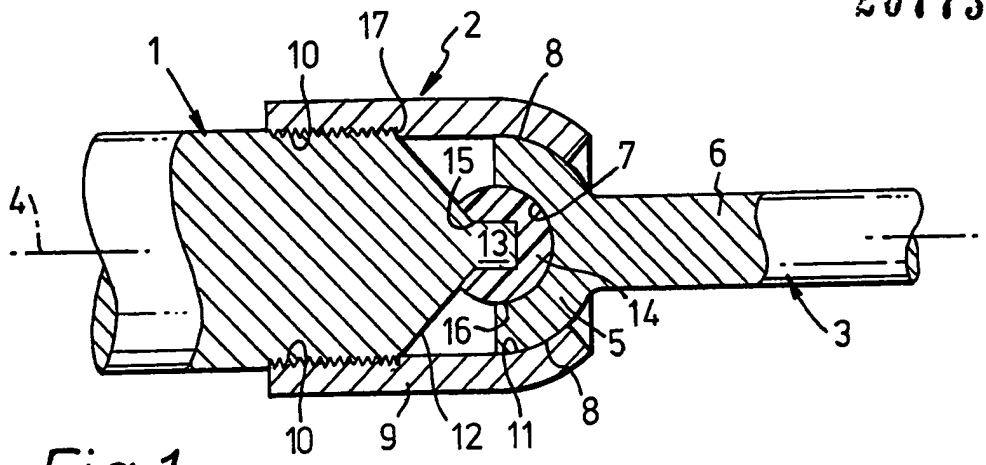

Fig.1.

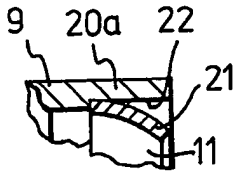

Fig.3.

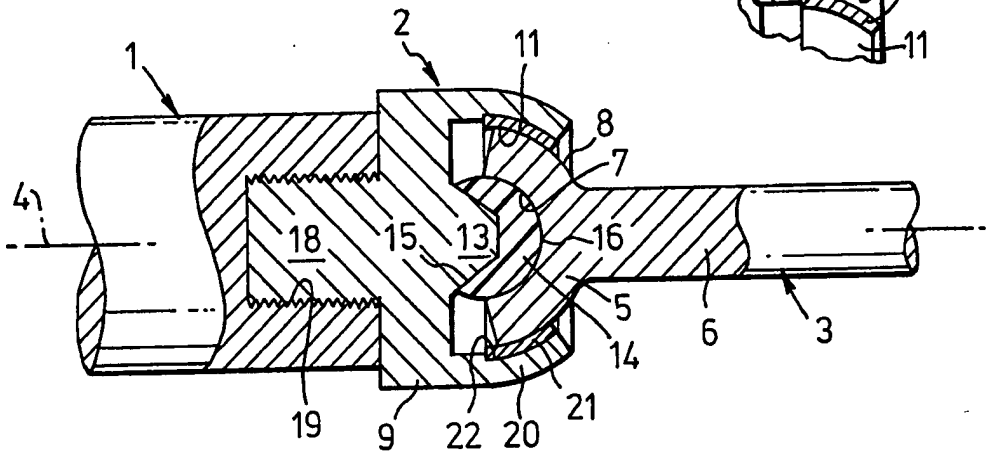

Fig.2.

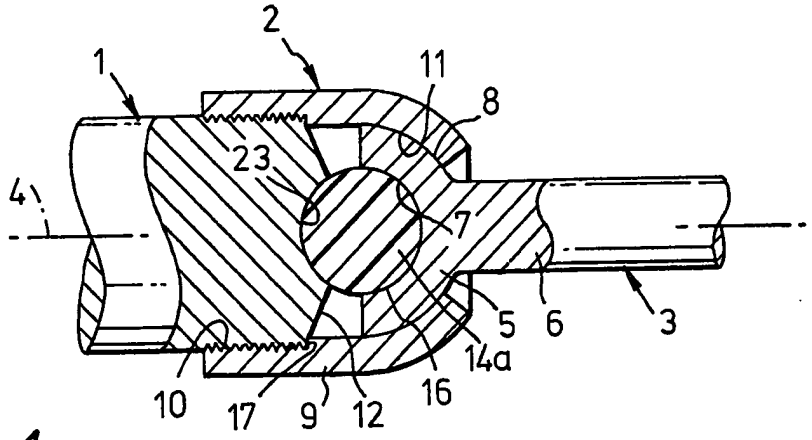

Fig.4.

SPECIFICATION
A ball joint assembly

This invention relates to a ball joint assembly for use in a steering assembly.

Ball joints are well known components for steering systems where they are generally used to connect together two members, say in a steering linkage, to provide universal pivotal movement between those members and permit the transmission of tensile and compressive forces between those members. One of such members in the steering system may be longitudinally displaceable, for example the rack in a rack and pinion steering gear and a ball joint is generally used to couple the rack bar to a steering arm or tie rod in the steering system. Essentially components in a steering system must be reliable and for commercial viability they should be relatively inexpensive to manufacture, easy to assemble and have the number of parts in a particular component maintained at a minimum consistent with reliability. The invention is more particularly concerned with a ball joint for use in an in-line steering system in which two members extend longitudinally relative to each other in tandem along a longitudinal axis and have adjacent ends interconnected through a universal joint by which one of those members can exhibit gyrational pivotal movement relative to the other member about the axis and through which universal joint axially directed compressive and tensile forces are intended to be transmitted between the two members during use of those members in a steering system. This particular form of ball joint assembly is exemplified in a rack and pinion steering system where tie rods extend in-line from opposite ends of the rack bar and are connected thereto through universal ball joints. Although being well known in steering systems, ball joints which have hitherto been proposed may generally be regarded as expensive to manufacture and assemble in view of the multi-part components which are necessary in their construction (particularly in providing a pre-load between the bearing surfaces), as unsuitable for viable use in an in-line steering system as aforementioned or do not maintain efficient contact between the bearing surfaces during the pivotal movement which is intended of the joint. For example, the ball joint assembly disclosed in U.K. Specification No. 992,100 is an expensive multi-part structure which incorporates a complex spring biasing arrangement for urging together part spherical bearing surfaces of the joint; the joint is unsuitable in an in-line system since it would necessitate expensive re-design of the ball joint housing to permit location of the spring biasing; further the area of sliding engagement between co-operating part spherical bearing surfaces in the joint (effected between a ball-like member and a cup-like member within which the ball is received) is variable depending upon the pivotal position between the two members which the joint interconnects. U.K. Specification No. 508,890 similarly provides an expensive multi-part structure in which spring biasing means is provided for loading the joint and similarly to the disclosure in 992,100 is commercially suitable only for a universal joint arrangement between two members which are generally perpendicular to each other since re-design of the spring loading for use in an in-line arrangement would not be viable commercially. Our German Specification No. 2,814,234 discloses a ball joint assembly for use in an in-line system in which a ball ended tie rod is pivotally connected to the end of a rack bar and in which relatively few components are required to permit ease of assembly; in such an arrangement however a considerable proportion of manufacturing costs can be attributed to the forming of the ball end on the tie rod where accurate machining is necessary to an extent which renders the assembly relatively expensive. Furthermore, the relatively large size of the ball end in the assembly of Specification No. 2,814,234 which is necessary to provided appropriate bearing surfaces for reliability in the steering system demands a relatively large size housing within which the ball end is retained — this can be disadvantageous where a compact steering system may be required for a motor vehicle.

It is an object of the present invention to provide a ball joint assembly for use in a steering system where two members are interconnected in-line through a universal joint and which alleviates the disadvantages of the aforementioned prior proposals.

According to the present invention there is provided a ball joint assembly for use in a steering system comprising two members extending substantially longitudinally relative to each other in-line along a longitudinal axis and having adjacent ends thereof interconnected through a universal joint by which one of said members can exhibit gyrational pivotal movement relative to the other member about said axis and through which axially directed compressive and tensile forces can be transmitted between said members; said universal joint comprising a ball cup on the end of one member having concentric inner and outer part spherical bearing surfaces; a tubular housing on the end of the second member having a generally annular part spherical inner bearing surface which is complementary to and within which the outer bearing surface is received to slidably co-operate therewith with part length of the one member extending through the annulus of the housing; a resilient plastics ball member which is substantially complementary to and is slidably received in the inner bearing surface of the ball cup to be substantially concentric therewith, said ball member providing a part spherical bearing surface the area of contact of which with the said inner bearing surface is maintained constant for the intended pivotal movement between the two members; means restraining the ball member from radial displacement relative to the longitudinal axis and means for axially displacing

the first and second members relatively towards each other during assembly of the universal joint to apply axially compressive forces to the ball member whereby a pre-load is maintained in the joint solely by the expansive forces in the ball member which result from said compressive forces.

In its simplest form the in-line connection between the two members of the ball joint assembly of the present invention can consist of three components, namely the two members (one of which has a ball cup end and the other of which has its end formed with the tubular housing integral therewith) and the ball member; in this simple arrangement the ball member is retained within the tubular housing and the pre-load can be achieved by deforming the housing (for example by swaging) over the outer part spherical bearing surface of the ball cup to apply the required compressive forces to the plastics ball member. Generally however the housing will be a separate component which is screw threadedly or otherwise retained on the end of the second member. Preferably screw threaded engagement between the housing and the second member is provided so that during the screw threaded assembly of these components the ball cup end of the one member which is captured within the housing is drawn axially towards the other member with the consequence that the ball member is subjected to compressive forces between the two members to pre-load the universal joint — in this arrangement the housing will usually consist of a tubular component where one end of the tube is screw threaded for engagement with the second member and the other end is preformed to provide the internal bearing surface.

The ball member may be wholly or partly spherical and in the latter case its part spherical bearing surface should be sufficient to ensure that it maintains full bearing surface contact with the inner bearing surface of the ball cup throughout the intended pivotal movement of the joint. Since the ball member is received within the ball cup it will be apparent that the diameter of the ball member can be considerably less than that required for the ball end of a ball joint such as that disclosed in our German Specification No. 2,814,234 and thus the axial length of the joint may be compacted as compared with that in our German Specification.

A spherical ball member can be retained from radial displacement relative to the longitudinal axis of the joint by location of such member within a seating, preferably a complementary part spherical seating, either in the housing or in the end of the second member. With a part spherical ball member however such member may be restrained from the said radial displacement by a socket and spigot engagement between the ball member and either the housing or the second member; for example, the ball member may be provided with a socket by which it is located within the housing by receiving a spigot or nose provided either as part of the housing or on the end of the second member.

If required, the part spherical bearing surfaces, that is the outer such surface on the ball cup or the inner such surface in the housing can be located on a lining or pad of required bearing material carried by the ball cup or housing as appropriate.

From the aforegoing it will be apparent that the ball joint assembly of the present invention requires very few components; it particularly alleviates the necessity of having biasing spring and means for adjusting or locating such springs to pre-load the joint; is easy to assemble and its assembly may be carried out by unskilled labour. (particularly if the screw threaded housing as aforementioned is arranged so that when it is screwed on to the second member to a maximum extent as may be determined by stop means, the desired compressive forces will be applied to the plastics ball member to give a required pre-load), and the required components may be manufactured inexpensively (particularly the ball cup ended member where the ball cup can be cold formed to a finished size within tight tolerances thereby avoiding the necessity for accurate and expensive machining).

Embodiments of ball joint assemblies constructed in accordance with the present invention will now be described, by way of example only, with reference to the accompanying illustrative drawings, in which:

Figure 1 illustrates a first embodiment in part axial section in which a part spherical ball member provides pre-load in the joint by axial compression of that member between the first and second members of the joint;

Figure 2 illustrates a second embodiment in part axial section in which a part spherical ball member provides pre-load in the joint by axial compression of that member between the one member of the joint and a housing by deformation of the housing to subject the ball member to compressive forces;

Figure 3 shows part of the housing in the embodiment of Figure 2 prior to deformation of the housing; and

Figure 4 illustrates a third embodiment in part axial section in which a spherical ball member provides pre-load in the joint by axial compression of that member between the first and second members of the joint.

The ball joint assemblies illustrated are for rack and pinion steering systems as are well known in the art and more particularly show one cylindrical end of a rack bar 1 coupled through a universal joint 2 with a tie rod 3. Conventionally the other end of the rack bar 1 will be coupled to a further tie rod in a similar manner to that shown so that the rack bar and tie rods form an in-line arrangement along a longitudinal axis 4 (which may be regarded as the axis of the rack bar 1 along which the latter is displaceable by rotation of the pinion). The universal joint 2 is intended to permit gyrational pivotal movement of the tie rod 3 relative to the rack bar 1 about the axis 4 and to permit axially directed compressive and tensile

forces to be transmitted through the components 1 and 3 during use of the steering system in effecting a steering manoeuvre from the rack bar and through the tie rods 3.

The tie rod 3 has a ball cup end 5 extending from which is a cylindrical shank 6. The ball cup 5 has concentric inner and outer part spherical bearing surfaces 7 and 8 respectively and is conveniently made by cold forming to its finished size.

The ball cup 5 is located and captured within and by a housing 9 mounted on the end of the rack bar 1.

In the embodiment of Figure 1 the housing 9 is wholly tubular and has at one end an internal screw thread which mates with an external thread on the rack bar (as indicated at 10) while its other end is pre-formed to provide a part spherical, generally annular internal bearing surface 11 which is complementary to, and slidably receives, the outer bearing surface 8 of the ball cup with the shank 6 extending through the open end of the housing. The end of the rack bar 1 has a frusto conical form 12 tapering to a spigot 13 on which is mounted a ball member 14. The ball 14 is of resilient plastics material such as polyester elastomer and has a socket 15 within which the spigot 13 is received and a part spherical bearing surface 16 which is complementary to and is slidably received by the inner bearing surface 7 of the tie rod 3.

On assembly of the ball joint in Figure 1 the shaft 6 is passed through the housing 9 to mate the bearing surfaces 8 and 11 and thereafter the housing 9 is screwed on to the end of the rack bar 1 with the ball 14 fitted thereto so that the ball engages with the bearing surface 7. As the housing 9 is screwed on to the rack bar end it will be apparent that the rack bar and tie rod are displaced axially towards each other and in so doing apply axially compressive forces to the ball 14. These axially compressive forces (or the expansive forces in the ball) react on the co-operating bearing surfaces 8, 11 and 7, 16 to provide a pre-load which is maintained in the universal joint solely by the compressive forces applied to the ball member. Desirably the dimensions of the components in the universal joint and the resilient characteristics of the ball 14 are arranged so that when the housing 9 is screwed fully on to the rack bar 1 (which is conveniently determined by an internal shoulder on the housing abutting an external shoulder on the rack bar as indicated at 17) the pre-load in the joint is that which is required. It will be seen from Figure 1 that the bearing surface 16 is a major proportion of the outer surface of the ball 14 and this together with the clearance provided by the frusto conically formed end 12 of the rack bar can permit a considerable degree of pivotal movement to the tie rod 3 whilst ensuring that throughout such movement full bearing surface contact is maintained on the inner bearing surface 7 of the ball cup by the ball 14. The co-operating spigot 13 and ball 14 whilst providing a convenient means for locating the ball during assembly of the joint also serves to restrain the ball 14 from axial displacement relative to the axis 4.

In the embodiment of Figures 2 and 3 the housing 9 is part tubular and has a closed end carrying a male threaded spigot 18 which is engaged with a female threaded socket 19 in the end of the rack bar 1. The threaded engagement 18 and 19 provides a convenient means of mounting the housing 9 on the rack bar but other mountings can be employed, for example the housing may be welded to, or may be formed integral, with the rack bar. The other end 20 of the housing 9 is tubular to receive the ball cup 5 and is formed to capture the ball cup and retain its inner bearing surface 7 in sliding engagement with the bearing surface 16 of the ball 14 in a similar manner to the Figure 1 arrangement. The inner bearing surface 11 of the housing 9 is carried on a pre-formed, generally annular, pad of bearing material 21 which is conveniently received and secured in a recess 22 in the wall of the tubular housing part 20. From Figure 2 it will be seen that the spigot 13 on which is mounted the ball 14 is formed integral with the closed end of the housing 9. Clearly the closed end of the housing 9 precludes the possibility of locating the ball cup 5 within the inner bearing surface 11 by passing the tie rod through the housing in the manner in which the ball joint in Figure 1 is assembled. Assembly of the Figure 2 arrangement is achieved by initially having the wall 20 of the tubular housing part substantially cylindrical as indicated at 20*a* in Figure 3. The ball cup 5 with the preformed bearing pad 21 mounted thereon is then located within the confines of the cylindrical wall 20*a* (as indicated in Figure 3) so that the pad 21 is partly received within the recess 22 and thereafter wall 20*a* is swaged by rolling or crimpling radially inwardly against the pad 21 to secure the joint with the ball 14 received within the bearing surface 7. During swaging of the housing wall 20*a* against the ball cup 5 the tie rod and rack bar will be displaced relatively towards each other and thereby apply axially compressive forces to the ball member which are determined by the swaging operation to provide the desired pre-load in the joint which pre-load again is maintained by the expansive forces in the ball 14 created by the compression to which it has been subjected. By providing the pre-formed bearing pad 21 it will be realised that the tubular wall 20*a* does not have to be swaged to provide an accurate part spherical bearing surface.

The embodiment in Figure 4 is similar to that in Figure 1 where pre-load in the universal joint 2 is achieved by subjecting a resilient plastics ball to compressive forces between the ball cup 5 and the rack bar 1 as the housing 9 is screwed on to the rack bar. In the Figure 4 embodiment however the ball is spherical and is restrained from radial displacement relative to the axis 4 of the rack bar by its location within a complementary part spherical seating 23 provided in the frusto conically formed end 12 in the rack bar.

CLAIMS

1. A ball joint assembly for use in a steering system comprising two members extending substantially longitudinally relative to each other in-line along a longitudinal axis and having adjacent ends thereof interconnected through a universal joint by which one of said members can exhibit gyrational pivotal movement relative to the other member about said axis and through which axially directed compressive and tensile forces can be transmitted between said members; said universal joint comprising a ball cup on the end of one member having concentric inner and outer part spherical bearing surfaces; a tubular housing on the end of the second member having a generally annular part spherical inner bearing surface which is complementary to and within which the outer bearing surface is received to slidably co-operate therewith with part length of the one member extending through the annulus of the housing; a resilient plastics ball member which is substantially complementary to and is slidably received in the inner bearing surface of the ball cup to be substantially concentric therewith, said ball member providing a part spherical bearing surface the area of contact of which with the said inner bearing surface is maintained constant for the intended pivotal movement between the two members; means restraining the ball member from radial displacement relative to the longitudinal axis and means for axially displacing the first and second members relatively towards each other during assembly of the universal joint to apply axially compressive forces to the ball member whereby a pre-load is maintained in the joint solely by the expansive forces in the ball member which result from said compressive forces.

2. An assembly as claimed in claim 1 in which the ball cup is captured within the housing by deformation of the housing over the outer part spherical bearing surface of the ball cup.

3. An assembly as claimed in claim 2 in which the said deformation is by swaging.

4. An assembly as claimed in claim 1 in which the housing is preformed to receive the outer part spherical bearing surface of the ball cup.

5. An assembly as claimed in any one of the preceding claims in which the housing comprises a tubular component which is axially adjustable on the second member to apply axially compressive forces to the resilient ball member by drawing the ball cup which is captured within the housing axially towards the second member.

6. An assembly as claimed in claim 5 in which the housing is in screw threaded engagement with the second member for said axial adjustment.

7. An assembly as claimed in either claim 5 or claim 6 in which stop means is provided which determines the extent of axial adjustment between the housing and the second member to provide a predetermined axially compressive loading on the ball member.

8. An assembly as claimed in either claim 2 or claim 3 in which the resilient ball member is pre-loaded by the application of axially compressive forces thereto by the said deformation of the housing.

9. An assembly as claimed in any one of claims 2, 3 and 8 in which the housing comprises a tubular part length within which the ball cup is received and which part length is closed at an end thereof adjacent to the second member by means which is integral with the tubular part.

10. An assembly as claimed in any one of claims 2, 3, 8 and 9 in which the housing is integral with the second member.

11. An assembly as claimed in any one of claims 2, 3 and 8 to 10 in which the housing is in screw threaded engagement with the second member.

12. An assembly as claimed in any one of the preceding claims in which the resilient plastics ball member is spherical.

13. An assembly as claimed in claim 12 in which the spherical ball member is restrained from radial displacement relative to the longitudinal axis and to the second member by a seating within which it is partly received and which seating is fixed radially relative to the second member.

14. An assembly as claimed in claim 13 in which the seating is part spherical and complementary to the ball member.

15. An assembly as claimed in either claim 13 or claim 14 when appendant to claim 5 in which the seating is located on the second member.

16. An assembly as claimed in either claim 13 or claim 14 when appendant to claim 9 in which the seating is located on the closed end of the housing.

17. An assembly as claimed in any one of claims 1 to 11 in which the resilient plastics ball member is part spherical and is restrained from radial displacement relative to the longitudinal axis and to the second member by engagement of a socket with a spigot one of which is located on the ball member and the other of which is fixed radially relative to the second member.

18. An assembly as claimed in claim 17 in which the socket is located in the ball member.

19. An assembly as claimed in either claim 17 or claim 18 when appendant to claim 5 in which the socket and spigot engagement is between the ball member and the second member.

20. An assembly as claimed in either claim 17 or claim 18 when appendant to claim 9 in which the socket and spigot engagement is between the ball member and the closed end of the housing.

21. An assembly as claimed in any one of the preceding claims in which the ball member is restrained from radial displacement relative to the longitudinal axis and to the second member and housing on a frusto conical surface within the enclosure of the housing and which surface converges as it approaches the ball member and the first member to provide clearance for pivotal movement of the ball cup within the housing.

22. An assembly as claimed in any one of the preceding claims in which at least one of the part spherical inner bearing surface of the tubular

housing and the outer bearing surface of the ball cup is located on at least one lining or pad of bearing material carried between the ball cup and the housing.

23. An assembly as claimed in claim 22 when appendant to claim 2 in which a lining of bearing material provides the part spherical inner bearing surface of the tubular housing and said lining is retained within the housing by the said deformation of the housing.

24. An assembly as claimed in any one of the preceding claims in which the ball member is of a polyester elastomer.

25. A ball joint assembly substantially as herein described with reference to Figure 1 of the accompanying illustrative drawings.

26. A ball joint assembly substantially as herein described with reference to Figures 2 and 3 of the accompanying illustrative drawings.

27. A ball joint assembly substantially as herein described with reference to Figure 4 of the accompanying illustrative drawings.

28. A steering system which includes a ball joint assembly as claimed in any one of the preceding claims.

29. A system as claimed in claim 28 and of the rack and pinion kind in which the two members comprise a rack bar and a tie rod.

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